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Watanabe

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(54) **SHUTTER MECHANISM FOR CONTROLLING DEVELOPER SUPPLIED FROM A DEVELOPER SUPPLYING DEVICE**

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(52) **U.S. Cl.**
CPC ***G03G 15/0886*** (2013.01)

(58) **Field of Classification Search**
CPC G03G 15/0886
USPC 399/260, 262
See application file for complete search history.

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(57) **ABSTRACT**

A developing device includes a shutter moving portion and a receiving-port shutter that are combined together, with a recessed portion and a projecting portion thereof being in engagement with each other, so that a developer receiving port is opened or shut. A gap is provided between the recessed portion and the projecting portion, and the shutter moving portion is swingable with respect to the receiving-port shutter. Even if the shutter moving portion vibrates by following the displacement of a toner conveying portion, the vibration is not transmitted to the receiving-port shutter because the shutter moving portion absorbs the vibration, preventing the receiving-port shutter from flapping. Thus, the leakage of developer that may occur particularly in a case of package shipment of the developing device and an image forming apparatus is suppressed.

5 Claims, 6 Drawing Sheets

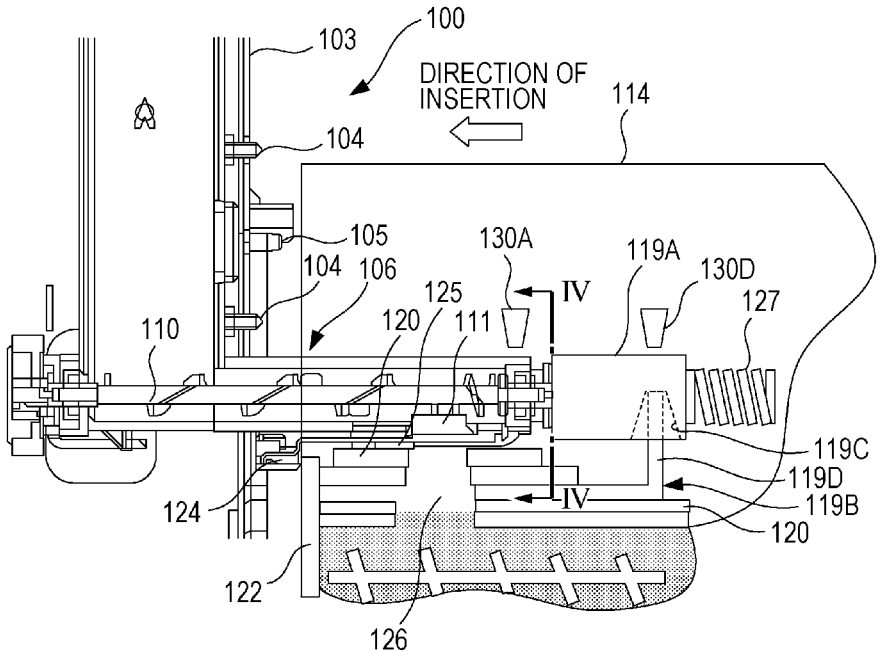


FIG. 1

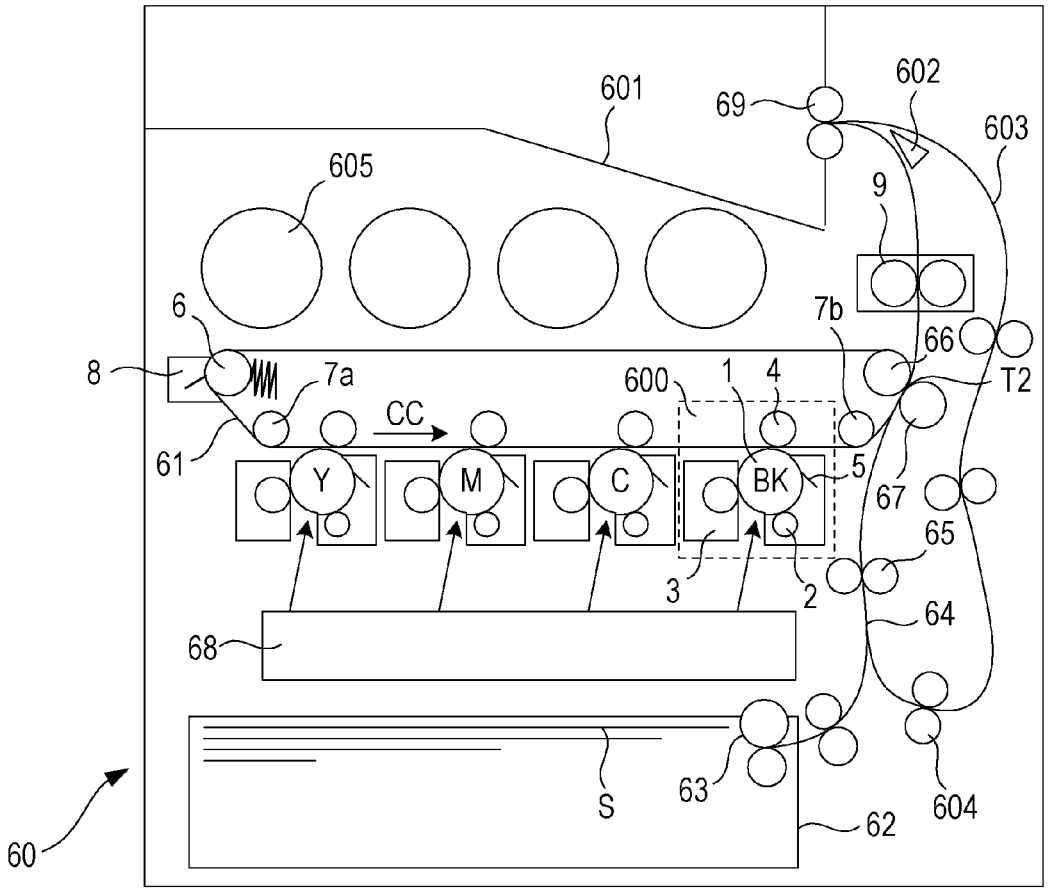

601
69
602
603
605
9
6
7b
66
8
7a
600
1
4
T2
CC
61
Y
M
C
BK
5
67
65
3
2
64
68
S
63
604
62
60

FIG. 2A

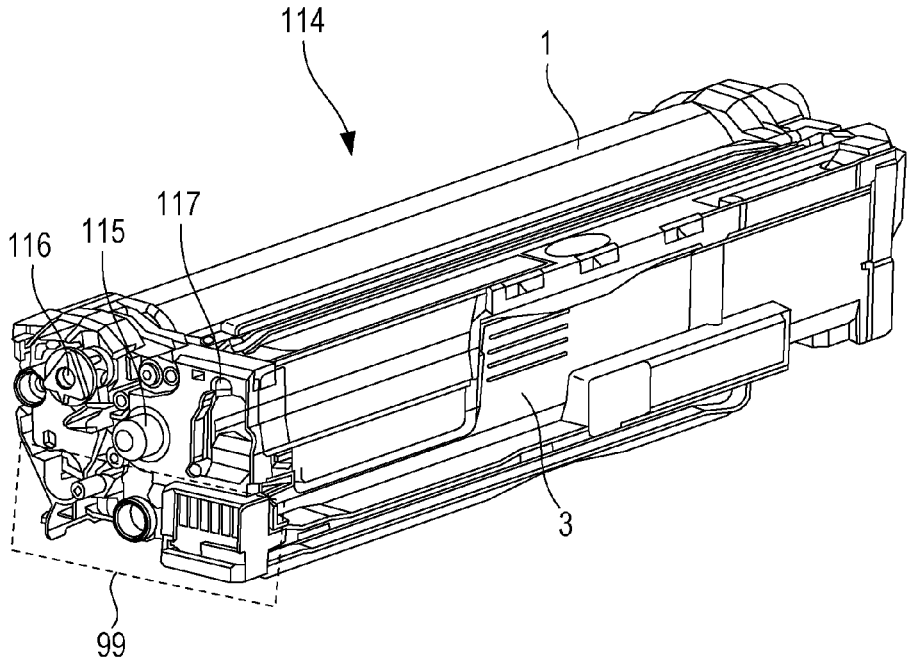


FIG. 2B

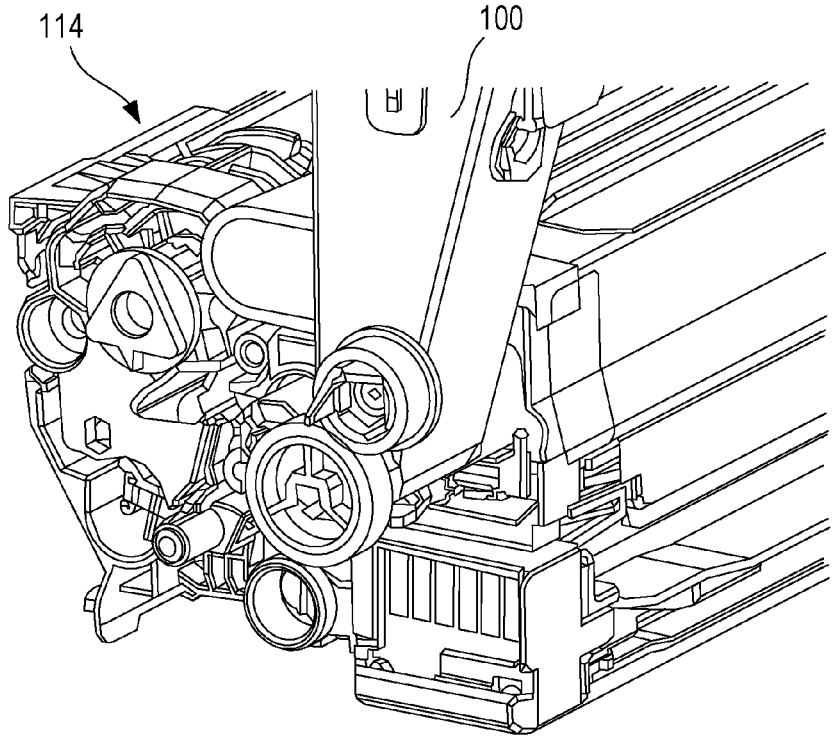


FIG. 3

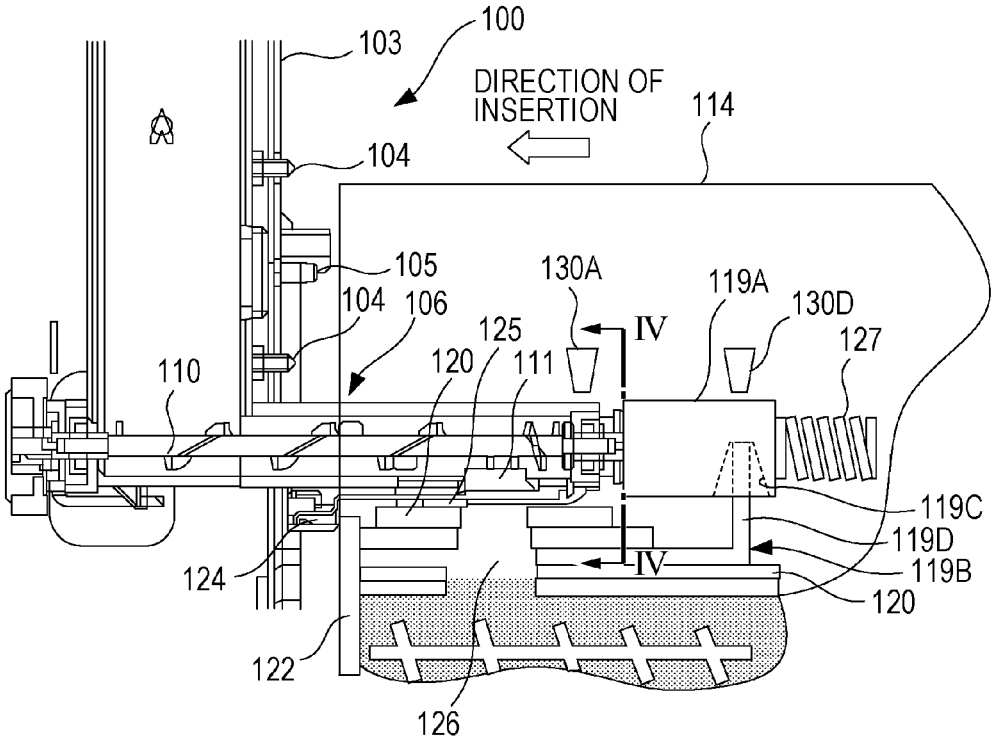

100
103
DIRECTION OF INSERTION
114
104
105
130A
119A
130D
104
106
125
IV
127
110
120
111
119C
119D
IV
119B
124
120
122
126

FIG. 4

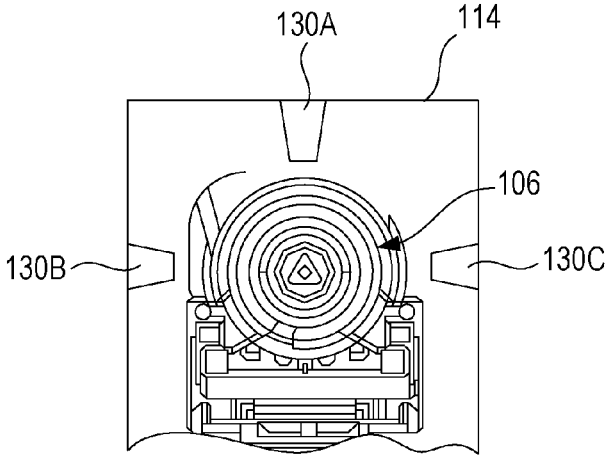

130A
114
106
130B
130C

FIG. 5

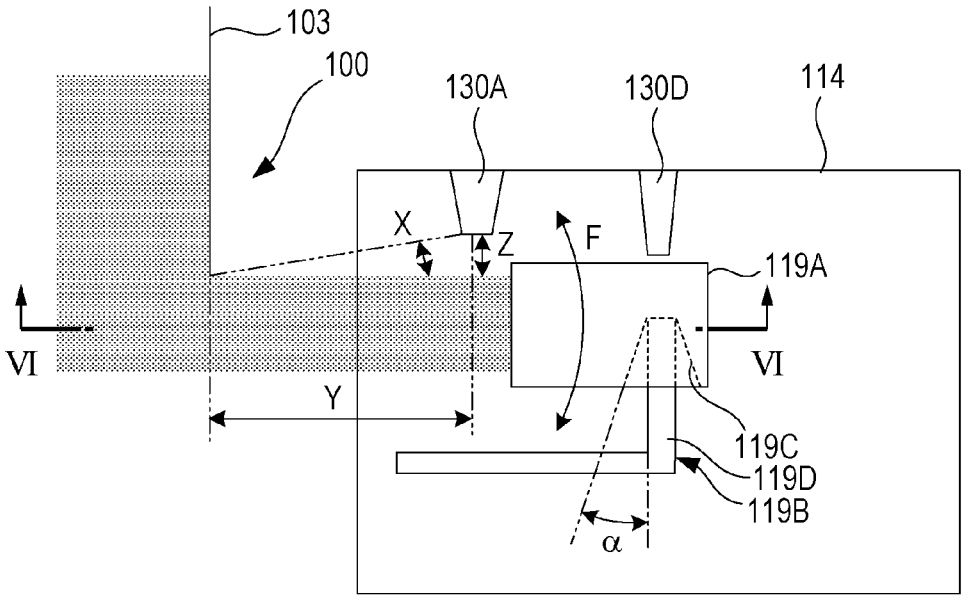

103
100
130A
130D
114
X
Z
F
119A
VI
VI
Y
119C
119D
119B
α

FIG. 6

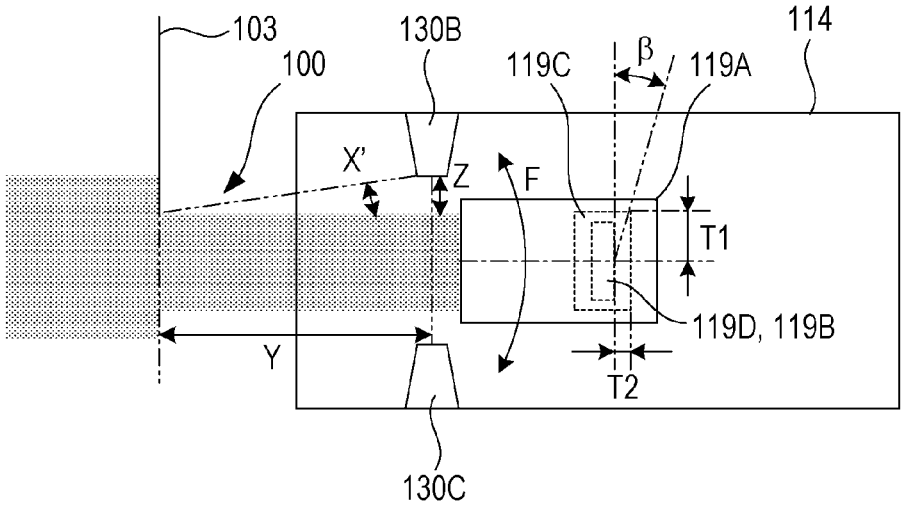

103
130B
114
100
119C
β
119A
X'
Z
F
T1
119D, 119B
Y
T2
130C

FIG. 7A

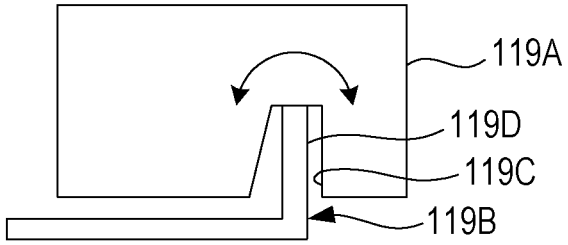


FIG. 7B

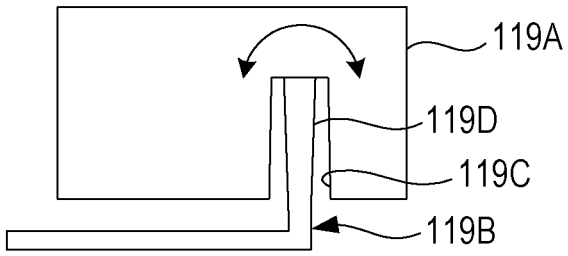


FIG. 7C

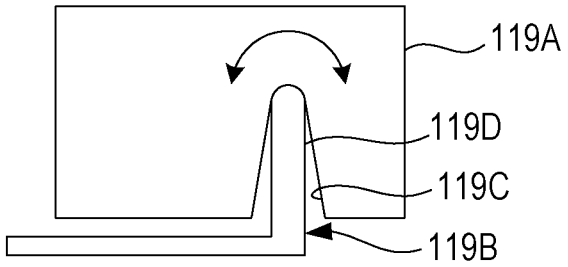
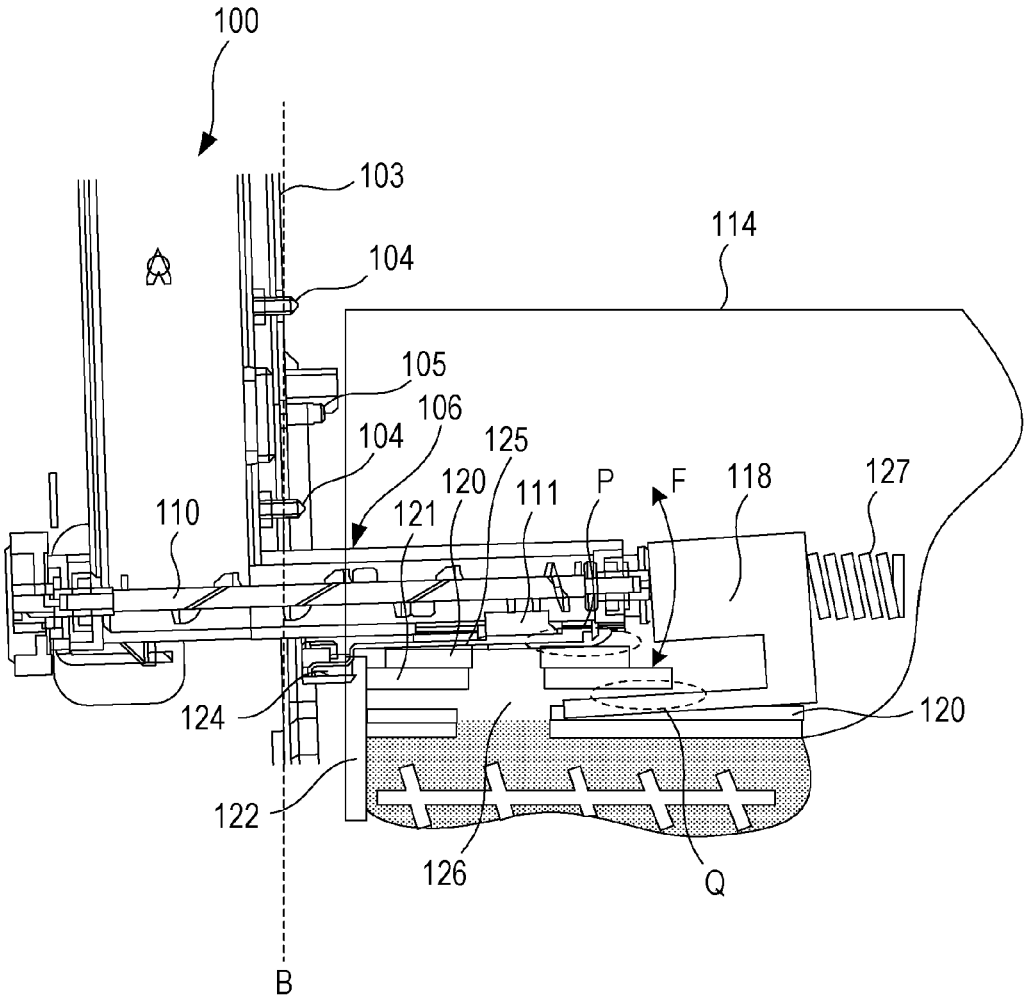


FIG. 8


100
103
104
114
105
106
104
125
120
111
P
F
118
127
110
121
124
120
122
126
Q
B

SHUTTER MECHANISM FOR CONTROLLING DEVELOPER SUPPLIED FROM A DEVELOPER SUPPLYING DEVICE

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a developing device that is attachable to and detachable from a developer supplying device provided in a body of an image forming apparatus. Specifically, the present invention relates to a shutter mechanism that opens and shuts a developer receiving port that receives developer supplied from the developer supplying device.

2. Description of the Related Art

There are known image forming apparatuses including developing devices and developer supplying devices. The developing devices each develop an electrostatic image formed on a photoconductive drum into a toner image with, for example, a two-component developer composed of a toner and a magnetic carrier. The developer supplying devices each supply the developer to the developing device. The developing device is provided either as a sole component or as a unit called process cartridge including other associated image forming elements (such as a photoconductor drum), and is detachably attached to the body of the image forming apparatus. The process cartridge (the developing device) is connected to the developer supplying device provided in the body of the image forming apparatus. In the body of the image forming apparatus, a developer receiving port provided in the process cartridge communicates with a developer supply port provided in the developer supplying device.

Such an image forming apparatus includes a shutter mechanism that opens and shuts the developer supply port in conjunction with the attaching or detaching of the process cartridge so that the developer does not leak from the developer supply port of the developer supplying device when the process cartridge is attached to or detached from the body of the image forming apparatus (see Japanese Patent Laid-Open No. 2012-108457).

Another known process cartridge includes a shutter mechanism that opens and shuts a developer receiving port of a developing device (see Japanese Patent Laid-Open No. 2012-8457). In this shutter mechanism, when the image forming apparatus is powered for the first time, a shutter that has been at a position for shutting the developer receiving port is slid to a position for opening the developer receiving port in accordance with the rotation of a stirring member provided in a developer container.

Process cartridges (developing devices), which are consumables, are each shipped while being set in the body of an image forming apparatus. In the case of the shutter mechanism disclosed by Japanese Patent Laid-Open No. 2012-108457, a gap tends to be produced at the connection between the developer supply port and the developer receiving port because of vibrations, impacts, or the like that may be applied to the process cartridge during transportation, installation, or the like. In such a case, the developer may leak from the gap.

In the case of the shutter mechanism disclosed by Japanese Patent Laid-Open No. 2012-8457, the above leakage of the developer from the connection between the developer supply port and the developer receiving port is not likely to occur. However, this shutter mechanism requires a large torque out of the necessity of not only stirring and conveying the developer but also moving the shutter, and therefore requires a high-performance motor. Moreover, the shutter mechanism has a complicated configuration with an increased number of components. Because of this, a process cartridge including a shutter mechanism as described, has high costs despite being a consumable.

SUMMARY OF THE INVENTION

The present invention provides a developing device including a shutter mechanism having a simple configuration for suppressing the leakage of developer that may occur particularly when the developing device is packed and shipped in a state of being set in an image forming apparatus.

According to an aspect of the present invention, there is provided a developing device that is attachable to and detachable from a body of an image forming apparatus including a developer supplying device. The developing device includes a developer receiving port that receives developer supplied from the developer supplying device, a shutter that opens and shuts the developer receiving port, and a shutter moving portion that comes into contact with the developer supplying device with the insertion of the developing device into the body of the image forming apparatus. The shutter is slidable in a direction of insertion of the developing device into the body of the image forming apparatus and is movable between a position for opening the developer receiving port and a position for shutting the developer receiving port. When the shutter moving portion comes into contact with the developer supplying device, the shutter moving portion moves the shutter from the position for shutting the developer receiving port to the position for opening the developer receiving port. The shutter moving portion is in engagement with the shutter in such a manner as to be swingable.

Further features of the present invention will become apparent from the following description of exemplary embodiments with reference to the attached drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic diagram of an image forming apparatus.

FIGS. **2**A and **2**B are perspective views of a process cartridge according to an embodiment of the present invention.

FIG. **3** is a sectional view of the process cartridge according to the embodiment of the present invention that is taken in the longitudinal direction of the process cartridge.

FIG. **4** is a sectional view of the process cartridge according to the embodiment of the present invention that is taken along line IV-IV illustrated in FIG. **3**, the line IV-IV extending vertically to the longitudinal direction of the process cartridge.

FIG. **5** is a schematic side view illustrating a receiving-port-shutting mechanism.

FIG. **6** is a schematic top view illustrating the receiving-port-shutting mechanism.

FIGS. **7**A to **7**C are sectional views illustrating exemplary shapes of a recessed portion and a projecting portion.

FIG. **8** is a sectional view of a comparative process cartridge that is taken in the longitudinal direction of the process cartridge.

DESCRIPTION OF THE EMBODIMENTS

A developing device according to an embodiment of the present invention will now be described with reference to

FIGS. **1** to **8**. First, an outline of an image forming apparatus including the developing device, as a process cartridge, according to the embodiment of the present invention will be described with reference to FIG. **1**.

Image Forming Apparatus

FIG. **1** is a sectional view of a color image forming apparatus **60** employing an electrophotographic method. The image forming apparatus **60** is of an intermediate-transfer tandem type in which image forming units (process cartridges) **600** for four respective colors are provided in such a manner as to face an intermediate transfer belt **61**. The intermediate-transfer tandem type is regarded as a recent-year mainstream because of its high productivity and compatibility to the conveyance of various kinds of media.

In the image forming apparatus **60**, a recording medium S is conveyed as follows. Recording media S are stacked in a recording medium storage (cassette) **62**. The recording media S are each fed from the recording medium storage **62** by a pair of feed rollers **63** in accordance with the timing of image formation and by, for example, a friction-separation method. The recording medium S thus fed by the pair of feed rollers **63** is conveyed to a pair of registration rollers **65** provided at a position in a conveyance path **64**. The pair of registration rollers **65** corrects the skew of the recording medium S and adjusts the timing of conveyance of the recording medium S. Then, the recording medium S is conveyed to a secondary transfer site T**2**. The secondary transfer site T**2** corresponds to a transfer nip provided between a secondary-transfer inner roller **66** and a secondary-transfer outer roller **67** that face each other. At the secondary transfer site T**2**, a predetermined pressure and a predetermined electrostatic load bias are applied to toner images formed on the recording medium S, whereby the toner images are fixed to the recording medium S.

In accordance with the timing of the above conveyance of the recording medium S to the secondary transfer site T**2**, images are formed and conveyed to the secondary transfer site T**2** as described below, following the description of the image forming units **600**. The image forming units **600** for the respective colors basically have the same configuration except the colors of toners. Therefore, the image forming unit **600** for black (BK) will be described as a representative.

The image forming unit **600** (a process cartridge) basically includes a photoconductive drum (photoconductor or image bearing member) **1**, a charging device **2**, a developing device **3**, a photoconductive-drum cleaner **5**, and so forth. The surface of the photoconductive drum **1**, which rotates when driven, is uniformly charged in advance by the charging device **2**. Then, an electrostatic latent image is formed by an exposure device **68** that is driven in accordance with a signal corresponding to image information. The electrostatic latent image thus formed on the photoconductive drum **1** is developed and visualized with a toner by the developing device **3**. The toner image thus formed on the photoconductive drum **1** is subjected to a predetermined pressure and a predetermined electrostatic load bias that are applied by a primary transfer device **4** provided across the intermediate transfer belt **61** from the image forming unit **600**, whereby the toner image on the photoconductive drum **1** is transferred for the primary transfer to the intermediate transfer belt **61**. A small amount of residual toner remaining on the photoconductive drum **1** after the transfer is collected by the photoconductive-drum cleaner **5** and is to be reused in the subsequent image formation. While the image forming apparatus **60** illustrated in FIG. **1** includes four image forming units **600** for yellow (Y), magenta (M), cyan (C), and black (BK), the number of image forming units **600** provided for respectively different colors is not limited to four, and the order of arrangement of the image forming units **600** is not limited to that illustrated in FIG. **1**, either. The developer used in the developing device **3** is a two-component developer as a mixture of a toner and a magnetic carrier. The toner is supplied to the developing device **3** from a toner bottle **605**, which is set in the image forming apparatus **60**, via a toner supplying device (not illustrated).

Now, the intermediate transfer belt **61** will be described. The intermediate transfer belt **61** is an endless belt that is stretched around a tension roller **6**, the secondary-transfer inner roller **66**, and follower rollers **7***a* and **7***b*. The intermediate transfer belt **61** rotates, when driven, in a direction indicated by arrow CC illustrated in FIG. **1**. The secondary-transfer inner roller **66** also functions as a driving roller that drives the intermediate transfer belt **61**. The image forming units **600** for Y, M, C, and BK perform the above-described image forming process for the four respective colors in parallel with one another, and toner images are transferred for the primary transfer to the intermediate transfer belt **61** in such a manner as to be sequentially superposed one on top of another from the one formed by the most upstream image forming unit **600**. Ultimately, a full-color toner image is obtained on the intermediate transfer belt **61**. The full-color toner image is then conveyed to the secondary transfer site T**2**. Residual toner that has passed through the secondary transfer site T**2** is collected by a transfer-belt cleaner **8**.

The recording-medium-conveying process and the image forming process described above are performed synchronously with each other, whereby the recording medium S and the full-color toner image meet at the secondary transfer site T**2**, where the secondary transfer is performed. Subsequently, the recording medium S is conveyed to a fixing device **9**, where the toner image is melted and is fixed to the recording medium S with a predetermined pressure and a predetermined heating energy applied thereto. The recording medium S now having the fixed image is discharged onto a discharge tray **601** by a pair of discharge rollers **69** that rotate in the forward direction, or is further conveyed for duplex image formation.

If duplex image formation is required, after the recording medium S is conveyed with the forward rotation of the pair of discharge rollers **69** until the trailing end of the recording medium S passes a switching member **602**, the pair of discharge rollers **69** undergo backward rotation, whereby the leading end and the trailing end of the recording medium S are switched, and the recording medium S is conveyed into a duplex conveyance path **603**. Then, synchronously with the subsequent job, the recording medium S is conveyed into the conveyance path **64** again by a pair of refeed rollers **604**. The conveying process and the image forming process on the other side of the recording medium S performed thereafter are the same as those described above, and description thereof is omitted.

Process Cartridge

The process cartridge (hereinafter denoted by **114**) according to the embodiment of the present invention will now be described. FIG. **2**A is a perspective view of the process cartridge **114**. FIG. **2**B is an enlarged view illustrating a part of the process cartridge **114** that has been attached to the image forming apparatus **60**. The process cartridge **114** is a unit including the developing device **3** and other associated image forming elements. In FIG. **2**A, as a matter of convenience, the associated image forming elements except the photoconductive drum **1** are not illustrated.

The process cartridge **114** is detachably attached to the image forming apparatus **60** (see FIG. **1**) by being slid into

the image forming apparatus **60** in the longitudinal direction thereof (in the direction of insertion). As illustrated in FIG. **2**A, the process cartridge **114** has a conveying-portion-insertion slot **117** as an insertion portion in a side face thereof (on the near side in FIG. **2**A) to be connected to the image forming apparatus **60**. To attach the process cartridge **114** to the image forming apparatus **60**, a toner conveying portion **106** of a toner supplying device **100** (see FIG. **3** to be referred to below) is inserted into the conveying-portion-insertion slot **117**, and the process cartridge **114** is slid along the toner conveying portion **106**, thereby being inserted into the body of the image forming apparatus **60**. The process cartridge **114** is pushed into the body of the image forming apparatus **60** until the process cartridge **114** reaches the position illustrated in FIG. **2**B, thereby being connected to the toner supplying device **100**. In the state illustrated in FIG. **2**B, a developer receiving port **126** provided in the process cartridge **114** and a developer supply port **111** provided in the toner supplying device **100** communicate with each other (see FIG. **3**). In this state, the developer is supplied from the toner supplying device **100** into the developing device **3** via the developer supply port **111** and the developer receiving port **126**.

The process cartridge **114** further has, on the side face thereof to be connected to the image forming apparatus **60**, a developing-device-drive-inputting portion **115**, a photoconductive-drum-drive-inputting portion **116**, a contact portion **99**, and so forth that are provided for respective purposes of, for example, the transmission of driving forces and the supply of electric power from the image forming apparatus **60** to the process cartridge **114**. That is, the process cartridge **114** does not operate alone but operates when attached to the image forming apparatus **60** and thus receiving the driving forces, the electric power, and so forth from the body of the image forming apparatus **60**.

Toner Supplying Device

The toner supplying device **100** to be connected to the process cartridge **114** will now be described with reference to FIG. **3**. The toner supplying device **100** as a developer supplying device is fixed to the body of the image forming apparatus **60**. Specifically, the toner supplying device **100** has two positioning bosses **104** provided at upper and lower positions, respectively, thereof. The positioning bosses **104** are fitted into respective holes provided in a rear plate **103** that is fixed to the body of the image forming apparatus **60**, whereby the toner supplying device **100** is positioned. The toner supplying device **100** thus positioned is fastened to the rear plate **103** with a screw **105**. A body-side driving unit (not illustrated) is provided on the rear side (the left side in FIG. **3**) of the toner supplying device **100**, that is, across the toner supplying device **100** from the positioning bosses **104**. The body-side driving unit is connected to a stirring member **110**.

A toner-bottle-holding member (not illustrated) that is attached to the rear plate **103** is provided above the toner supplying device **100**. The toner supplying device **100** and the tonner-bottle-holding member are connected to each other but are both sealed with a sealing member (not illustrated) interposed therebetween. The toner bottle **605** (see FIG. **1**) is connectable to the toner-bottle-holding member.

The toner supplying device **100** includes the toner conveying portion **106** having a shape that is fittable into the conveying-portion-insertion slot **117** provided in the process cartridge **114**. As illustrated in FIG. **3**, the toner conveying portion **106** as a conveying portion projects toward the process cartridge **114**. The toner conveying portion **106** includes the stirring member **110** that stirs and conveys the toner. The stirring member **110** is rotatably provided in the toner conveying portion **106**. The toner conveying portion **106** has the developer supply port **111** on the downstream side in the direction of toner conveyance. The toner is discharged from the developer supply port **111** to the outside of the toner conveying portion **106**.

The conveyance of the toner in the toner supplying device **100** will now be described. The toner is supplied from the toner bottle **605** (see FIG. **1**) in such a manner as to drop from the top of the toner supplying device **100** toward the toner conveying portion **106** with the gravitational force, and accumulates on the upstream side of the stirring member **110** in the direction of toner conveyance in the toner conveying portion **106**. When the body-side driving unit (not illustrated) provided for the toner supplying device **100** receives a toner supply signal from the image forming apparatus **60**, the body-side driving unit drives the stirring member **110** to rotate. The stirring member **110** has a screw structure in which a stirring blade made of a nonmagnetic material is spirally provided around a rotating shaft. Hence, when the stirring member **110** rotates, the toner accumulated on the upstream side in the direction of toner conveyance is stirred and conveyed toward the process cartridge **114** in the toner conveying portion **106**. The toner thus conveyed in the toner conveying portion **106** by the stirring member **110** is discharged from the developer supply port **111** to the outside of the toner conveying portion **106**.

In the toner supplying device **100** configured as described above, if the developer supply port **111** is left open when the process cartridge **114** is attached to or detached from the image forming apparatus **60**, the toner may leak from the developer supply port **111**. Therefore, the toner supplying device **100** is provided with a supply-port-shutting mechanism that opens and shuts the developer supply port **111**. The supply-port-shutting mechanism includes a shutter pushing member **124**, a supply-port shutter **125**, and a spring (not illustrated). The supply-port shutter **125** is connected to the shutter pushing member **124** and is attached to the toner conveying portion **106** in such a manner as to be slidable between a position for shutting the developer supply port **111** and a position for opening the developer supply port **111** in conjunction with the insertion and removal of the process cartridge **114** into and from the image forming apparatus **60**. The shutter pushing member **124** operates in conjunction with the insertion and removal of the process cartridge **114** into and from the image forming apparatus **60**. Specifically, the shutter pushing member **124** is constantly urged by the spring exerting a moving force acting in a direction in which the developer supply port **111** is shut. When the process cartridge **114** is inserted into the image forming apparatus **60**, the supply-port shutter **125** is moved to the position for opening the developer supply port **111** against the urging force of the spring. When the process cartridge **114** is removed from the image forming apparatus **60**, the supply-port shutter **125** is made to follow the movement of the process cartridge **114** by the spring and is moved to the position for shutting the developer supply port **111**. Thus, the supply-port shutter **125** opens the developer supply port **111** with the attaching of the process cartridge **114** to the body of the image forming apparatus **60**, and shuts the developer supply port **111** with the removal of the process cartridge **114** from the body of the image forming apparatus **60**.

It is the recent-year mainstream that image forming apparatuses are shipped with process cartridges being set therein (hereinafter such a shipment method is referred to as package shipment) so that the users can perform the initial

installation work as easily as possible and can immediately output images by simply turning on the apparatuses. Considering such circumstances, it is necessary to prevent the developer from leaking from the connection between the developer supply port **111** of the toner supplying device **100** and the developer receiving port **126** of the process cartridge **114** (see FIG. **3**) during the transportation of the image forming apparatus **60**.

The reasons why the developer leaks from the connection in the case of package shipment will now be described in comparison with a known example illustrated in FIG. **8**. In the package shipment, an image forming apparatus is packed in a cardboard box with cushioning materials provided in gaps between the image forming apparatus and the bottom surface, side surfaces, and top surfaces of the cardboard box. The image forming apparatus thus packed is transported by any of various means, for example, by air, by sail, or by land. Considering such conditions for transportation, a transportation test was conducted in which the image forming apparatus was vibrated within an expected range of frequencies. The result of the transportation test shows the following. When the image forming apparatus was vibrated, some components of the image forming apparatus were displaced, giving some backlash to a shutter member **118** and producing gaps between the shutter member **118** and peripheral components. Consequently, the developer leaked from the gaps.

More specifically, for example, if the image forming apparatus is vibrated in the direction in which the shutter member **118** is movable (the horizontal direction in FIG. **8**), the toner bottle **605** (see FIG. **1**) and the toner-bottle-holding member (not illustrated) are also vibrated in the same direction, thereby vibrating peripheral components significantly. Since the toner-bottle-holding member is fixed to the rear plate **103**, the vibration of the toner-bottle-holding member is transmitted to the toner supplying device **100** via the rear plate **103**. The toner-bottle-holding member is also directly connected to the toner supplying device **100**. Therefore, when the toner-bottle-holding member vibrates, the toner supplying device **100** that is fixed to the rear plate **103** with substantially a single screw **105** is displaced, i.e., rotates, about a position near the position where the toner supplying device **100** is fastened with the screw **105**. Particularly, the toner conveying portion **106** of the toner supplying device **100** vibrates significantly in a direction indicated by arrow F illustrated in FIG. **8**. Actually, the toner conveying portion **106** vibrates three-dimensionally, including the direction indicated by arrow F and the direction of movement of the shutter member **118**. That is, the toner conveying portion **106** is displaced in such a manner as to vibrate along a conical locus.

In the state where the process cartridge **114** is set in the image forming apparatus, the tip of the toner conveying portion **106** is in contact with the shutter member **118** that is urged by a spring **127**. Therefore, when the toner conveying portion **106** vibrates along a conical locus as described above, the shutter member **118** follows the movement of the toner conveying portion **106** and is displaced. A sealing member **120** that seals the developer in is provided below the shutter member **118**. The sealing member **120** is made of a flexible material. Therefore, as illustrated in FIG. **8**, the shutter member **118** may be tilted every time the toner conveying portion **106** is displaced. (Note that dotted line B illustrated in FIG. **8** is a vertical line, and the toner supplying device **100** is tilted with respect to line B.) That is, the vibration makes the shutter member **118** flap. If the shutter member **118** flaps, a gap is produced (in an enclosed area Q in FIG. **8**) between the shutter member **118** and a shutter holding member **121** that holds the shutter member **118** by pressing down a portion of the shutter member **118**, and the developer may leak from the gap. Furthermore, the toner conveying portion **106** is displaced relative to the process cartridge **114** in a direction intersecting the direction of movement of the shutter member **118**. Therefore, another gap tends to be produced (in an enclosed area P in FIG. **8**) between the toner conveying portion **106** and the sealing member **120** provided above the shutter holding member **121** and being in contact with the toner conveying portion **106**, and the developer may leak from the gap.

In view of the above reasons, to prevent the leakage of the developer from the connection between the developer supply port **111** and the developer receiving port **126**, the displacement of the toner supplying device **100** (specifically, the toner conveying portion **106**) that is caused by the vibration of the image forming apparatus as a whole only needs to be prevented from being transmitted to the shutter member **118**. Furthermore, the process cartridge **114** as a whole only needs to be made to follow the movement of the toner conveying portion **106** that is displaced with the vibration of the image forming apparatus as a whole. Hence, in the process cartridge **114** according to the embodiment of the present invention, the above two features are embodied. The two features will now be described.

The first feature is as follows. As illustrated in FIG. **3**, the process cartridge **114** includes a receiving-port-shutting mechanism that includes two separate members, which are a shutter moving portion **119**A and a receiving-port shutter **119**B. The receiving-port-shutting mechanism corresponds to the known shutter member **118** (see FIG. **8**), which includes only one component. The receiving-port-shutting mechanism as a shutter device includes the shutter moving portion **119**A, the receiving-port shutter **119**B, and the spring **127** as an elastic member. The receiving-port shutter **119**B is attached to a developer container **122** in such a manner as to be slidable between a position for shutting the developer receiving port **126** and a position for opening the developer receiving port **126**. The sealing member **120**, made of a flexible material, is provided between the receiving-port shutter **119**B and the developer container **122** so as to seal the developer in. The receiving-port shutter **119**B includes a projecting portion **119**D extending toward the shutter moving portion **119**A. The shutter moving portion **119**A has a recessed portion **119**C that receives the projecting portion **119**D. As to be described below, the receiving-port shutter **119**B and the shutter moving portion **119**A are combined with each other, with the projecting portion **119**D and the recessed portion **119**C being in engagement with each other. The combination of the receiving-port shutter **119**B and the shutter moving portion **119**A functions as a single shutter member. A predetermined size of a gap (also referred to as play) is provided between the recessed portion **119**C and the projecting portion **119**D. The gap allows the shutter moving portion **119**A to swing with respect to the receiving-port shutter **119**B.

The shutter moving portion **119**A is provided on the rear side in the conveying-portion-insertion slot **117** (see FIG. **2**A) and is constantly urged by the spring **127** with a moving force acting in a direction in which the shutter moving portion **119**A shuts the developer receiving port **126**. When the process cartridge **114** is inserted into the body of the image forming apparatus **60**, the shutter moving portion **119**A comes into contact with the toner conveying portion **106** and is moved. Specifically, as the process cartridge **114** is inserted into the body of the image forming apparatus **60**,

the shutter moving portion **119**A moves the receiving-port shutter **119**B, against the urging force of the spring **127**, to the position for opening the developer receiving port **126**. On the other hand, as the process cartridge **114** is removed from the body of the image forming apparatus **60**, the spring **127** moves the receiving-port shutter **119**B via the shutter moving portion **119**A to the position for shutting the developer receiving port **126**.

As illustrated in FIG. **3**, the process cartridge **114** has a rib **130**D as a first restricting portion provided above the shutter moving portion **119**A. The rib **130**D restricts the displacement of the shutter moving portion **119**A in the upward direction in FIG. **3** (a direction intersecting the direction of movement of the receiving-port shutter **119**B). Hence, the vibration of the shutter moving portion **119**A is suppressed, and the receiving-port shutter **119**B is prevented from coming off the shutter moving portion **119**A. In the embodiment, the distance between the rib **130**D and the shutter moving portion **119**A (the allowable length of movement) illustrated in FIG. **3** is set to a smaller value than the length of engagement between the recessed portion **119**C and the projecting portion **119**D (the length by which the projecting portion **119**D is inserted into the recessed portion **119**C in the vertical direction in FIG. **3**).

The second feature is as follows. As illustrated in FIG. **4**, the process cartridge **114** has ribs **130**A to **130**C as second restricting portions or restricting portions. The ribs **130**A to **130**C are provided in the conveying-portion-insertion slot **117** (in the insertion portion, see FIG. **2**) and are arranged in such a manner as to surround the toner conveying portion **106** inserted into the process cartridge **114**. If the toner conveying portion **106** is displaced along a conical locus with the vibration of the image forming apparatus **60** as a whole, any of the ribs **130**A to **130**C come into contact with the toner conveying portion **106**. In the embodiment, even if the toner conveying portion **106** is displaced along a conical locus, the developer does not leak from the connection between the developer supply port **111** of the toner supplying device **100** and the developer receiving port **126** of the process cartridge **114** (see FIG. **3**). Specifically, the relative movements of the toner conveying portion **106** and the process cartridge **114** are restricted by the ribs **130**A to **130**C such that an area defined by vertically projecting the developer supply port **111** is positioned within an area defined as the developer receiving port **126**.

With the presence of the ribs **130**A to **130**C, the process cartridge **114** follows the movement of the toner conveying portion **106** such that the developer supply port **111** is positioned within the area defined by the developer receiving port **126** in the vertical direction as described above. For example, if the toner conveying portion **106** is displaced upward in FIG. **4** because of any vibration, the toner conveying portion **106** comes into contact with the rib **130**A, whereby the process cartridge **114** is also displaced upward. If the toner conveying portion **106** is displaced in the horizontal direction in FIG. **4**, the toner conveying portion **106** comes into contact with either the rib **130**B or the rib **130**C, whereby the process cartridge **114** is also displaced in the horizontal direction. Thus, making the entirety of the process cartridge **114** follow the movement of the toner conveying portion **106** maintains the relative position of the toner supplying device **100** (specifically, the toner conveying portion **106**) with respect to the positions of the shutter moving portion **119**A and the receiving-port shutter **119**B. That is, the ribs **130**A to **130**C restrict the relative displacement of the toner supplying device **100** in a direction intersecting the direction of movement of the receiving-port shutter **119**B such that the toner supplying device **100** is not displaced relative to the shutter moving portion **119**A and the receiving-port shutter **119**B.

As described above, the shutter moving portion **119**A and the receiving-port shutter **119**B are combined with each other by making the recessed portion **119**C and the projecting portion **119**D engage with each other, whereby the shutter moving portion **119**A is swingable with respect to the receiving-port shutter **119**B. To embody such a configuration, in the state where the recessed portion **119**C and the projecting portion **119**D are in engagement with each other and the tip of the projecting portion **119**D and the bottom surface of the recessed portion **119**C are in contact with each other, gaps (play) need to be provided between the sidewalls of the recessed portion **119**C and the side surfaces of the projecting portion **119**D. To provide such a gap, the sidewalls of the recessed portion **119**C are each inclined at a predetermined angle with respect to a corresponding one of the side surfaces of the projecting portion **119**D that faces the sidewall. The angle of inclination is determined in association with the amount of displacement of the toner conveying portion **106** or the amount of displacement of the shutter moving portion **119**A. If the toner conveying portion **106** is displaced along a conical locus, the shutter moving portion **119**A vibrates by following the displacement of the toner conveying portion **106**. In the embodiment, this vibration is not transmitted to the receiving-port shutter **119**B because the shutter moving portion **119**A absorbs the vibration. Therefore, the receiving-port shutter **119**B is not displaced with respect to the developer receiving port **126**. As to be described below, the angle of displacement of the toner conveying portion **106** with respect to the process cartridge **114** is set to a value smaller than or equal to the angle of swing of the shutter moving portion **119**A with respect to the receiving-port shutter **119**B. Specifically, the ribs **130**A to **130**C restrict the angle of displacement of the toner conveying portion **106** and determine the angle of swing between the recessed portion **119**C and the projecting portion **119**D. This configuration will be described in more detail with reference to FIGS. **5** and **6**.

The above configuration of the process cartridge **114** will further be described with reference to FIG. **5** from the viewpoint of the amount of displacement of the toner conveying portion **106** in the vertical direction. Let the gap between the toner conveying portion **106** and the rib **130**A be Z, and the length from the base of the toner conveying portion **106** (the position of the rear plate **103** to which the toner supplying device **100** is fixed) to the rib **130**A be Y. Then, an angle of displacement X of the toner conveying portion **106** in the vertical direction is expressed as follows.

$$X=\tan^{-1}(Z/Y) \qquad \text{Expression 1}$$

To prevent the receiving-port shutter **119**B from following the displacement of the toner conveying portion **106** while allowing the shutter moving portion **119**A to follow the displacement of the toner conveying portion **106**, the angle of inclination α of the inclined sidewall of the recessed portion **119**C is set to a value larger than or equal to the angle of displacement X. For example, if the gap Z is 0.5 mm and the length Y is 150 mm, the angle of inclination α is set to a value larger than 0.19°. Such a relationship is established between the angle of inclination α and the amount of displacement of the toner conveying portion **106** in the vertical direction. A state where the gap Z between the toner conveying portion **106** and the rib **130**A is zero, that is, a state where the tip of the rib **130**A is to be in contact with the outer surface of the toner conveying portion **106**, is not

allowed in terms of tolerance because the process cartridge **114** may interfere with the toner conveying portion **106** when being inserted into the body of the image forming apparatus **60**. The above description of the amount of displacement of the toner conveying portion **106** in the vertical direction also applies to the amount of displacement of the shutter moving portion **119**A in the vertical direction, description of which is therefore omitted herein.

The toner conveying portion **106** also vibrates in the horizontal direction. The configuration of the process cartridge **114** will now be described with reference to FIG. **6** from the viewpoint of the amount of displacement of the toner conveying portion **106** in the horizontal direction. An angle of displacement X' of the toner conveying portion **106** in the horizontal direction is also expressed by Expression 1 give above. Note that, however, the symbol Z in Expression 1 now denotes the gap between the toner conveying portion **106** and the rib **130**B (or the rib **130**C). An angle of inclination β between the shutter moving portion **119**A and the receiving-port shutter **119**B is obtained from Expression 2 given below. In Expression 2, T**1** denotes the length from the center line of the projecting portion **119**D in the long-side direction of the projecting portion **119**D to a sidewall of the recessed portion **119**C, and T**2** denotes the gap between a surface of the projecting portion **119**D and a sidewall of the recessed portion **119**C that face each other in the short-side direction of the projecting portion **119**D.

$$\beta=\tan^{-1}(T1/T2) \qquad \text{Expression 2}$$

To prevent the receiving-port shutter **119**B from following the displacement of the toner conveying portion **106** while allowing the shutter moving portion **119**A to follow the displacement of the toner conveying portion **106**, T**1** and T**2** in Expression 1 are set to respective values that establish a relationship of $X<\beta$. Thus, the shape of the recessed portion **119**C of the shutter moving portion **119**A and the shape of the projecting portion **119**D of the receiving-port shutter **119**B are determined.

Hence, the shapes of the recessed portion **119**C and the projecting portion **119**D are not limited to those illustrated in FIG. **3** and may be, for example, any of those illustrated in FIGS. **7**A to **7**C. FIGS. **7**A to **7**C are sectional views illustrating exemplary shapes of the recessed portion **119**C and the projecting portion **119**D. As illustrated in FIG. **7**A, only one of the two sidewalls of the recessed portion **119**C may be inclined. As illustrated in FIG. **7**B, instead of giving an inclination to any of the sidewalls of the recessed portion **119**C, the projecting portion **119**D may have inclined surfaces in such a manner as to be widened toward the tip thereof. That is, either the recessed portion **119**C or the projecting portion **119**D only needs to have at least one inclined surface. As illustrated in FIG. **7**C, at least one of the tip of the projecting portion **119**D and the bottom surface of the recessed portion **119**C may be smoothly curved. Such a configuration makes it easier for the shutter moving portion **119**A to swing with respect to the receiving-port shutter **119**B.

The operation of the above receiving-port-shutting mechanism will now be described with reference to FIG. **3**. In the state where the process cartridge **114** is yet to be attached to the body of the image forming apparatus **60**, the shutter moving portion **119**A is positioned at the mouth of the conveying-portion-insertion slot **117** (see FIG. **2**), thereby closing the conveying-portion-insertion slot **117**. When the process cartridge **114** is pushed into the body of the image forming apparatus **60** such that the toner conveying portion **106** is inserted into the conveying-portion-insertion slot **117**, the tip of the toner conveying portion **106** comes into contact with the shutter moving portion **119**A. When the process cartridge **114** is further pushed into the body of the image forming apparatus **60**, the shutter moving portion **119**A that is urged by the spring **127** moves the receiving-port shutter **119**B to the position for opening the developer receiving port **126**.

Meanwhile, on the side of the toner supplying device **100**, when the process cartridge **114** is further pushed into the body of the image forming apparatus **60** after the tip of the toner conveying portion **106** comes into contact with the shutter moving portion **119**A, the developer container **122** of the process cartridge **114** comes into contact with the shutter pushing member **124**. Such a time difference is provided on an assumption that the toner drops from the developer supply port **111** when the supply-port shutter **125** is opened. Therefore, the developer receiving port **126** of the process cartridge **114** is opened in advance so that the toner assuredly drops into the developer container **122**. That is, in the embodiment, after the developer receiving port **126** is fully opened, the developer supply port **111** is opened.

When the process cartridge **114** is further pushed into the body of the image forming apparatus **60**, the shutter pushing member **124** slides in the direction of insertion of the process cartridge **114** and moves the supply-port shutter **125** to the position for opening the developer supply port **111**. Thus, the supply-port shutter **125** of the toner supplying device **100** and the receiving-port shutter **119**B of the process cartridge **114** reach the respective opening positions, allowing the developer supply port **111** and the developer receiving port **126** to communicate with each other.

As described above, the two members, i.e., the shutter moving portion **119**A and the receiving-port shutter **119**B are combined together by allowing the recessed portion **119**C and the projecting portion **119**D thereof to engage with each other. With such a configuration, the developer receiving port **126** of the process cartridge **114** is opened or shut. A predetermined gap is provided between the recessed portion **119**C and the projecting portion **119**D, and the shutter moving portion **119**A is swingable with respect to the receiving-port shutter **119**B by the size of the gap. In such a configuration, even if the shutter moving portion **119**A is vibrated by following the displacement of the toner conveying portion **106**, the vibration is not transmitted to the receiving-port shutter **119**B because the shutter moving portion **119**A absorbs the vibration. Therefore, the receiving-port shutter **119**B remains still with respect to the developer receiving port **126**, that is, the receiving-port shutter **119**B does not flap. In such a situation, no gap is produced at the connection between the developer supply port **111** and the developer receiving port **126**. Accordingly, the developer does not leak from the connection.

The process cartridge **114** has the ribs **130**A to **130**C that restrict the displacement of the toner supplying device **100** (specifically, the toner conveying portion **106**) and the rib **130**D that restricts the displacement of the shutter moving portion **119**A. The ribs **130**A to **130**C make the shutter moving portion **119**A and the receiving-port shutter **119**B follow the vibration of the toner supplying device **100**, whereas the rib **130**D suppresses the vibration of the shutter moving portion **119**A with respect to the receiving-port shutter **119**B. Thus, the receiving-port shutter **119**B becomes less flappy, and the leakage of the developer from the connection is more assuredly prevented.

Furthermore, the simple configuration of the shutter mechanism in which the shutter moving portion **119**A and

the receiving-port shutter **119**B are in engagement with each other lowers the manufacturing cost of the process cartridge **114**.

While the above embodiment concerns a case where the receiving-port shutter **119**B has a substantially L shape, the receiving-port shutter **119**B does not necessarily have such a shape and may have any other suitable shape such as a substantially T shape. While the above embodiment concerns a case where the receiving-port shutter **119**B has the projecting portion **119**D and the shutter moving portion **119**A has the recessed portion **119**C, the shutter moving portion **119**A may have the projecting portion **119**D and the receiving-port shutter **119**B may have the recessed portion **119**C.

According to the above embodiment of the present invention, a developing device including a shutter mechanism having a simple configuration for suppressing the leakage of developer that may occur particularly in the case of package shipment is provided.

While the present invention has been described with reference to exemplary embodiments, it is to be understood that the invention is not limited to the disclosed exemplary embodiments. The scope of the following claims is to be accorded the broadest interpretation so as to encompass all such modifications and equivalent structures and functions.

This application claims the benefit of Japanese Patent Application No. 2014-045415, filed Mar. 7, 2014, which is hereby incorporated by reference herein in its entirety.

What is claimed is:

1. A developing device that is attachable to and detachable from a body of an image forming apparatus including a developer supplying device, the developing device comprising:

a developer receiving port configured to receive developer supplied from the developer supplying device; and

a shutter mechanism configured to open and shut the developer receiving port according to a mounting action of the developing device,

wherein the shutter mechanism comprising:

a shutter configured to open and shut the developer receiving port; and

an engaging member configured to be movably provided together with the shutter and configured to movably engaged with the shutter,

wherein the engaging member is configured to contact with the developer supplying member according to a mounting action of the developing device, and according to a movement of the developing device toward a mounting position of the developing device in a state where the engaging member contacting with the developer supplying member, the shutter opens the developer receiving port, and

wherein the engaging member is configured to swing with respect to the shutter.

2. The developing device according to claim **1**,

wherein a projecting portion is arranged to either one of the engaging member and the shutter; and

wherein a recessed portion is arranged to the other one of the either one of the engaged member and the shutter, so as to be engaged with the projecting portion,

wherein a tip of the projecting portion is in contact with a bottom surface of the recessed portion, and

wherein a gap is produced between the recessed portion and the projecting portion so that the engaging member to be swingable with respect to the shutter using the tip of the projecting portion as a fulcrum.

3. The developing device according to claim **1**, wherein the gap between the projecting portion and the recessed portion becomes smaller toward the tip of the projecting portion when the projecting portion and the recessed portion are in engagement with each other.

4. The developing device according to claim **1**, wherein either one of the tip of the projecting portion and the bottom surface of the recessed portion is formed in a curved shape.

5. The developing device according to claim **1**, further comprising:

a restricting portion configured to restrict a relative position of the developer supplying device and the developing device when the relative position between the developer supplying device and the developing device is displaced in a state where the developing device is mounted,

wherein the angle of swing of the developer supplying device with respect to the developing device is set to a value smaller than or equal to the angle of swing of the engaging member with respect to the developing device.

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